

“The Scientific Advantages of an Antarctic Expedition.” By
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January 25,—Read February 24, 1898.

From a scientific point of view the advantages to be derived from a well-equipped and well-directed expedition to the Antarctic would, at the present time, be manifold. Every department of natural knowledge would be enriched by systematic observations as to the order in which phenomena coexist and follow each other in regions of the earth's surface about which we know very little or are wholly ignorant. It is one of the great objects of science to collect observations of the kind here indicated, and it may be safely said that without them we can never arrive at a right understanding of the phenomena by which we are surrounded, even in the habitable parts of the globe.

Before considering the various orders of phenomena, concerning which fuller information is urgently desired, it may be well to point out a fundamental topographical difference between the Arctic and Antarctic. In the northern hemisphere there is a polar sea almost completely surrounded by continental land, and continental conditions for the most part prevail. In the southern hemisphere, on the other hand, there is almost certainly a continent at the South Pole, which is completely surrounded by the ocean, and, in those latitudes, the most simple and extended oceanic conditions on the surface of the globe are encountered.

The Atmosphere.

One of the most remarkable features in the meteorology of the globe is the low atmospheric pressure at all seasons in the southern hemisphere south of latitude 45° S., with the accompanying strong westerly and north-westerly winds, large rain- and snow-fall, all round the South Polar regions. The mean pressure seems to be less than 29 inches, which is much lower than in similar latitudes in the northern hemisphere. Some meteorologists hold that this vast cyclonic system and low-pressure area continues south as far as the pole, the more southerly parts being traversed by secondary cyclones. There are, however, many indications that the extreme South Polar area is occupied by a vast anticyclone, out of which winds blow towards the girdle of low pressure outside the ice-bound region. In support of this view it is pointed out that Ross's barometric observations indicate a gradual rise in the pressure south of the latitude of 75° S., and all Antarctic voyagers agree that when near the ice the

majority of the winds are from the south and south-east, and bring clear weather with fall of temperature, while northerly winds bring thick fogs with rise of temperature.

All our knowledge of the meteorological conditions of the Antarctic is limited to a few observations during the midsummer months, and these indicate that the temperature of the snow-covered Antarctic continent is even at that time much lower than that of the surrounding sea. The anticyclonic area at the South Pole appears therefore to be permanent, and when in winter the sea-ice is for the most part continuous and extends far to the north, the anticyclonic area has most probably a much wider extension than in summer. This is indicated by the south-easterly winds which at times blow towards the southern point of the American continent in June and July.

All observations in high southern latitudes indicate an extremely low summer temperature. In winter we have no direct observations. The mean of Ross's air temperatures south of latitude 63° S. was 28.74° F., which is about the freezing point of sea-water, and his maximum temperature was 43.5° F. Both Wilkes and D'Urville observed pools of fresh water on several icebergs, and, when sailing along the ice barrier, Ross saw "gigantic icicles depending from every projecting point of its perpendicular cliffs,"* so it is probable that extensive melting sometimes takes place.

In the latitude of the Antarctic circle the air is frequently at or near the point of saturation, and precipitation takes place in the form of rain, sleet, snow, or hail. Most of the observations near the ice-covered land show, however, a much drier atmosphere, and in all probability precipitation over the Antarctic continent takes place in the form of fine snow crystals, such as is recorded in the interior of Greenland.

There would appear, then, to be good reasons for believing that the region of the South Pole is covered by what may be regarded practically as a great permanent anticyclone, with a much wider extension in winter than in summer. It is most likely that the prevailing winds blow out from the pole all the year round towards the surrounding sea, as in the case of Greenland, but, unlike Greenland, this area is probably seldom traversed by cyclonic disturbances.

But what has been stated only shows how little real knowledge we possess concerning the atmospheric conditions of high southern latitudes. It is certain, however, that even two years' systematic observations within these regions would be of the utmost value for the future of meteorological science.

* Ross, 'Antarctic Voyage,' vol. 1, p. 237.

Antarctic Ice.

From many points of view it would be important to learn something about the condition and distribution of Antarctic sea-ice during the winter months, and especially about the position and motions of the huge table-shaped icebergs at this and other seasons of the year. These flat-topped icebergs, with a thickness of 1200 or 1500 feet, with their stratification and their perpendicular cliffs, which rise 150 or 200 feet above and sink 1100 or 1400 feet below the level of the sea, form the most striking peculiarity of the Antarctic Ocean. Their form and structure seem clearly to indicate that they were formed on an extended land surface, and have been pushed out over low-lying coasts into the sea.

Ross sailed for 300 miles along the face of a great ice-barrier from 150 to 200 feet in height, off which he obtained depths of 1800 and 2400 feet. This was evidently the sea-front of a great creeping glacier or ice-cap just then in the condition to give birth to the table-shaped icebergs, miles in length, which have been described by every Antarctic voyager.

All Antarctic land is not, however, surrounded by such inaccessible cliffs of ice, for along the seaward faces of the great mountain ranges of Victoria Land the ice and snow which descend to the sea apparently form cliffs not higher than 10 to 20 feet, and in 1895 Kristensen and Borchgrevink landed at Cape Adare on a pebbly beach, occupied by a penguin rookery, without encountering any land-ice descending to the sea. Where a penguin rookery is situated, we may be quite sure that there is occasionally open water for a considerable portion of the year, and that consequently landing might be effected without much difficulty or delay, and further that a party, once landed, might with safety winter at such a spot, where the penguins would furnish an abundant supply of food and fuel. A properly equipped party of observers situated at a point like this on the Antarctic continent for one or two winters might carry out a most valuable series of scientific observations, make successful excursions towards the interior, and bring back valuable information as to the probable thickness of the ice-cap, its temperature at different levels, its rate of accumulation, and its motions, concerning all which points there is much difference of opinion among scientific men.

Antarctic Land.

Is there an Antarctic continent? It has already been stated that the form and structure of the Antarctic icebergs indicate that they were built up on, and had flowed over, an extended land surface. As these bergs are floated to the north and broken up in warmer lati-

tudes they distribute over the floor of the ocean a large quantity of glaciated rock fragments and land detritus. These materials were dredged up by the "Challenger" in considerable quantity, and they show that the rocks over which the Antarctic land-ice moved were gneisses, granites, mica-schists, quartziferous diorites, grained quartzites, sandstones, limestones, and shales. These lithological types are distinctively indicative of continental land, and there can be no doubt about their having been transported from land situated towards the South Pole. D'Urville describes rocky islets off Adélie Land composed of granite and gneiss. Wilkes found on an iceberg, near the same place, boulders of red sandstone and basalt. Borchgrevink and Bull have brought back fragments of mica-schists and other continental rocks from Cape Adare. Dr. Donald brought back from Joinville Island a piece of red jasper or chert containing Radiolaria and Sponge spicules. Captain Larsen brought from Seymour Island pieces of fossil coniferous wood, and also fossil shells of *Cucullæa*, *Cytherea*, *Cyprina*, *Teredo*, and *Natica*, having a close resemblance to species known to occur in lower Tertiary beds in Britain and Patagonia. These fossil remains indicate in these areas a much warmer climate in past times. We are thus in possession of abundant indications that there is a wide extent of continental land within the ice-bound regions of the southern hemisphere.

It is not likely that any living land-fauna will be discovered on the Antarctic continent away from the penguin rookeries. Still, an Antarctic expedition will certainly throw much light on many geological problems. Fossil finds in high latitudes are always of special importance. The pieces of fossil wood from Seymour Island can hardly be the only relics of plant life that are likely to be met with in Tertiary and even older systems within the Antarctic. Tertiary, Mesozoic, and Palæozoic forms are tolerably well developed in the Arctic regions, and the occurrence of like forms in the Antarctic regions might be expected to suggest much as to former geographical changes, such as the extension of Antarctica towards the north, and its connexion with, or isolation from, the northern continents, and also as to former climatic changes, such as the presence in pre-Tertiary times of a uniform temperature in the waters of the ocean all over the surface of the globe.

*Magnetic and Pendulum Observations, Geodetic Measurements, Tides,
and Currents.*

In any Antarctic expedition magnetic observations would, of course, form an essential part of the work to be undertaken, and the importance of such observations has been frequently dwelt upon by eminent physicists and navigators. Should a party of competent

observers be stationed at Cape Adare for two years, pendulum observations could be carried out there and at other points within the Antarctic, or even on the ice-cap and icebergs. It might be possible to measure a degree on the Antarctic continent or ice-cap, which would be a most useful thing to do. By watching the motions of the icebergs and ice from land at Cape Adare much would be learnt about oceanic currents, and our knowledge of the tides would be increased by a systematic series of tidal observations on the shores of the Antarctic continent, where we have at present no observations. The series of scientific observations here mentioned, and others that might be indicated, would fill up many gaps in our knowledge of the physical conditions of these high southern latitudes.

Depth of the Antarctic Ocean.

In regard to the depth of the ocean immediately surrounding the Antarctic continent we have at present very meagre information, and one of the objects of an Antarctic expedition would be to supplement our knowledge by an extensive series of soundings in all directions throughout the Antarctic and Southern Oceans. It would in this way be possible, after a careful consideration of the depths and marine deposits, to trace out approximately the outlines of the Antarctic continent. At the present time we know that Ross obtained depths of 100 to 500 fathoms all over the great bank extending to the east of Victoria Land, and somewhat similar depths have been obtained extending for some distance to the east of Joinville Island. Wilkes sounded in depths of 500 and 800 fathoms about 20 or 30 miles off Adélie Land. The depths found by the "Challenger" in the neighbourhood of the Antarctic circle were from 1300 to 1800 fathoms, and further north the "Challenger" soundings ranged from 1260 to 2600 fathoms. To the south-west of South Georgia, Ross paid out 4000 fathoms of line without reaching bottom. In the charts of depth which I have constructed I have always placed a deep sea in this position, for it appears to me that Ross, who knew very well how to take soundings, was not likely to have been mistaken in work of this kind.

The few indications which we thus possess of the depth of the ocean in this part of the world seem to show that there is a gradual shoaling of the ocean from very deep water towards the Antarctic continent, and, so far as we yet know, either from soundings or temperature observations, there are no basins cut off from general oceanic circulation by barriers or ridges, similar to those found towards the Arctic.

Deposits of the Antarctic Ocean.

The deposits which have been obtained close to the Antarctic continent consist of blue mud, containing glauconite, made up for the most part of detrital matters brought down from the land, but containing a considerable admixture of the remains of pelagic and other organisms. Further to the north there is a very pure diatom ooze, containing a considerable quantity of detrital matter from icebergs, and a few pelagic foraminifera. This deposit appears to form a zone right round the earth in these latitudes. Still further to the north the deposits pass in deep water, either into a Globigerina ooze, or into a red clay with manganese nodules, sharks' teeth, ear-bones of whales, and the other materials characteristic of that deep-sea deposit. Since these views, however, as to the distribution of deep-sea deposits throughout these high southern latitudes, are founded upon relatively few samples, it cannot be doubted that further samples from different depths in the unexplored regions would yield most interesting information.

Temperature of the Antarctic Ocean.

The mean daily temperature of the surface waters of the Antarctic, as recorded by Ross, to the south of latitude 63° S. in the summer months, varies from 27.3° to 33.6° , and the mean of all his observations is 29.85° . As already stated, his mean for the air during the same period is somewhat lower, being 28.74° . In fact, all observations seem to show that the surface water is warmer than the air during the summer months.

The "Challenger" observations of temperature beneath the surface indicate the presence of a stratum of colder water wedged between warmer water at the surface, and warm water at the bottom. This wedge-shaped stratum of cold water extends through about 12° of latitude, the thin end terminating about latitude 53° S., its temperature varying from 28° at the southern thick end to 32.5° at the northern thin end, while the temperature of the overlying water ranges from 29° in the south to 38° in the north, and that of the underlying water from 32° to 35° . This must be regarded as the distribution of temperature only during the summer, for it is improbable that during the winter months there is a warmer surface layer.

In the greater depths of the Antarctic, as far south as the Antarctic circle, the temperature of the water varies between 32° and 35° F., and is not, therefore, very different from the temperature of the deepest bottom water of the tropical regions of the ocean. The presence of this relatively warm water in the deeper parts of the

Antarctic Ocean may be explained by a consideration of general oceanic circulation. The warm tropical waters which are driven southwards along the eastern coasts of South America, Africa, and Australia, into the great all-encircling Southern Ocean, there become cooled as they are driven to the east by the strong westerly winds. These waters, on account of their high salinity, can suffer much dilution with Antarctic water, and still be denser than water from these higher latitudes at the same temperature. Here the density observations and the sea-water gases indicate that the cold water found at the greater depths of the ocean probably leaves the surface and sinks towards the bottom in the Southern Ocean, between the latitudes of 45° and 56° S. These deeper, but not necessarily bottom, layers are then drawn slowly northwards towards the tropics, to supply the deficiencies there produced by evaporation and southward-flowing surface currents, and these deeper layers of relatively warm water appear likewise to be slowly drawn southwards to the Antarctic area to supply the place of the ice-cold currents of surface water drifted to the north. This warm underlying water is evidently a potent factor in the melting and destruction of the huge table-topped icebergs of the southern hemisphere. While these views as to circulation appear to be well established, still a fuller examination of these waters is most desirable at different seasons of the year, with improved thermometers and sounding machines. Indeed, all deep-sea apparatus has been so much improved as a result of the "Challenger" explorations, that the labour of taking specific gravity and all other oceanographical observations has been very much lessened.

Pelagic Life of the Antarctic Ocean.

In the surface waters of the Antarctic there is a great abundance of diatoms and other marine algæ. These floating banks or meadows form primarily not only the food of pelagic animals, but also the food of the abundant deep-sea life which covers the floor of the ocean in these south polar regions. Pelagic animals, such as copepods, amphipods, molluscs, and other marine organisms, are also very abundant, although species are fewer than in tropical waters. Some of these animals seem to be nearly, if not quite, identical with those found in high northern latitudes, and they have not been met with in the intervening tropical zones. The numerous species of shelled Pteropods, Foraminifera, Coccoliths and Rhabdoliths, which exist in the tropical surface waters, gradually disappear as we approach the Antarctic circle, where the shelled Pteropods are represented by a small *Limacina*, and the Foraminifera by only two species of *Globigerina*, which are apparently identical with those in the Arctic Ocean. A peculiarity of the tow-net gatherings made by the "Challenger"

Expedition in high southern latitudes, is the great rarity or absence of the pelagic larvæ of benthonic organisms, and in this respect they agree with similar collections from the cold waters of the Arctic seas. The absence of these larvæ from polar waters may be accounted for by the mode of development of benthonic organisms, to be referred to presently. It must be remembered that many of these pelagic organisms pass most of their lives in water of a temperature below 32° F., and it would be most interesting to learn more about their reproduction and general life-history.

Benthos Life of the Antarctic Ocean.

At present we have no information as to the shallow-water fauna of the Antarctic continent; but, judging from what we do know of the off-lying Antarctic islands, there are relatively few species in the shallow waters in depths less than 25 fathoms. On the other hand, life in the deeper waters appears to be exceptionally abundant. The total number of species of Metazoa collected by the "Challenger" at Kerguelen in depths less than 50 fathoms was about 130, and the number of additional species known from other sources from the shallow waters of the same island is 112, making altogether 242 species, or thirty species less than the number obtained in eight deep hauls with the trawl and dredge in the Kerguelen region of the Southern Ocean, in depths exceeding 1260 fathoms, in which eight hauls 272 species were obtained. Observations in other regions of the Great Southern Ocean, where there is a low mean annual temperature, also show that the marine fauna around the land in high southern latitudes appears to be very poor in species down to a depth of 25 fathoms, when compared with the number of species present at the mud-line about 100 fathoms, or even at depths of about 2 miles.

In the year 1841 Sir James Clark Ross dredged off the Antarctic continent species which he recognised as the same as he had been in the habit of taking in equally high northern latitudes, and he suggested that they might have passed from the one pole to the other by way of the cold water of the deep sea. Subsequent researches show that, as with pelagic organisms, many of the bottom-living species are identical with, or closely allied to, those of the Arctic regions, and are not represented in the intermediate tropical areas. For instance, the most striking character of the shore-fish fauna of the Southern Ocean is the reappearance of types inhabiting the corresponding latitudes of the northern hemisphere, and not found in the intervening tropical zone. This interruption of continuity in the distribution of shore-fishes is exemplified by species as well as genera, and Dr. Günther enumerates eleven species and twenty-nine genera as illustrating this method of distribution.

The following are the eleven species:—*Chimæra monstrosa*, *Galeus canis*, *Acanthias vulgaris*, *Acanthias Blainvilli*, *Rhina squatina*, *Zeus faber*, *Lophius piscatorius*, *Centriscus scolopax*, *Engraulis encrasicolus*, *Clupea sprattus*, *Conger vulgaris*.

The genus by which the family Berycidae is represented in the southern temperate zone (*Trachichthys*) is much more nearly allied to the northern than to the tropical genera. "As in the northern temperate zone, so in the southern . . . the variety of forms is much less than between the tropics. This is especially apparent on comparing the number of species constituting a genus. In this zone, genera composed of more than ten species are the exception, the majority having only from one to five." . . . "Polyprion is one of those extraordinary instances in which a very specialised form occurs at almost opposite points of the globe, without having left a trace of its previous existence in, or of its passage through, the intermediate space."

Speaking of the shore-fishes of the Antarctic Ocean, Günther says: "The general character of the fauna of Magelhaen's Straits and Kerguelen's Land is extremely similar to that of Iceland and Greenland. As in the Arctic fauna, Chondropterygians are scarce, and represented by *Acanthias vulgaris* and species of *Raja* . . . As to Acanthopterygians, Cataphracti, and Scorpenidae are represented as in the Arctic fauna, two of the genera (*Sebastes* and *Agonus*) being identical. The Cottidae are replaced by six genera of Trachinidae, remarkably similar in form to Arctic types . . . Gadoid fishes reappear, but are less developed; as usual they are accompanied by *Myxine*. The reappearance of so specialised a genus as *Lycodes* is most remarkable."*

These statements with reference to shore-fishes might, with some modifications, be repeated concerning the distribution and character of all classes of marine invertebrates in high northern and high southern latitudes.† The "Challenger" researches show that nearly

* Günther, 'Study of Fishes,' pp. 282—290. Edinburgh. 1880.

† Ortmann, speaking of the Decapod Crustacea, says: "Nach dem Stande unserer jetzigen Kenntniss ist keine einzige bipolare Art bekannt" (Ortmann, 'Zoologische Jahrbücher,' Abth. f. Syst., &c., Bd. ix, p. 585, 1896). Henderson, in his report on the "Challenger" Anomura, in describing *Lithodes murrayi* from the Kerguelen region, says it "is apparently most closely allied to *Lithodes maia*" (from the North Atlantic), "but the latter species is of large size, and the spines on the carapace are more numerous and more uniformly equal in size" (Henderson, 'Zool. Chall. Exp.,' pt. 69, p. 44). Henderson writes me that these very slight differences were the only ones he could detect, and it seems evident that had the two specimens been taken from the same haul of the trawl, or from the same locality, they would never have been erected into two distinct species. Henderson writes me further that throughout the entire range of Crustacea there is no better illustration of bipolarity than that furnished by the Lithodidae. For instances of

250 species taken in high southern latitudes occur also in the northern hemisphere, but are not recorded from the tropical zone. Fifty-four species of sea-weed have also been recorded as showing a similar distribution.* Bipolarity in the distribution of marine organisms is a fact, however much naturalists may differ as to its extent and the way in which it has originated.

All those animals which secrete large quantities of carbonate of lime greatly predominate in the tropics, such as Corals, Decapod Crustacea, Lamellibranchs, and Gasteropods. On the other hand, those animals in which there is a feeble development of carbonate of lime structures predominate in cold polar waters, such as Hydroida, Holothurioidea, Annelida, Amphipoda, Isopoda, and Tunicata. This difference is in direct relation with the temperature of the water in which these organisms live, a much more rapid and abundant precipitate of carbonate of lime being thrown down in warm than in cold water by ammonium carbonate, one of the waste products of organic activity.

In the Southern and Sub-antarctic Ocean a large proportion of the Echinoderms develop their young after a fashion which precludes the possibility of a pelagic larval stage. The young are reared within or upon the body of the parent, and have a kind of commensal connection with her till they are large enough to take care of themselves. A similar method of direct development has been observed in eight or nine species of Echinoderms from the cold waters of the northern hemisphere. On the other hand, in temperate and tropical regions the development of a free-swimming larva is so entirely the rule that it is usually described as the normal habit of the Echinodermata. This similarity in the mode of development between Arctic and Antarctic Echinoderms (and the contrast to what takes place in the tropics) holds good also in other classes of Invertebrates, and probably accounts for the absence of free-swimming larvæ of benthonic animals in the surface gatherings in Arctic and Antarctic waters.

What is urgently required with reference to the biological problems here indicated is a fuller knowledge of the facts, and it cannot be doubted that an Antarctic expedition would bring back collections and observations of the greatest interest to all naturalists and physiologists, and without such information it is impossible to discuss with success the present distribution of organisms over the surface of the globe, or to form a true conception of the antecedent conditions by which that distribution has been brought about.

new species being made from purely geographical considerations, see 'Summary of Results, "Challenger" Expedition,' p. 1440-45.

* Murray and Barton, 'Phycological Memoirs of the British Museum,' part iii. London. 1895.

Concluding Remarks.

There are many directions in which an Antarctic Expedition would carry out important observations besides those already touched on in the foregoing statement. From the purely exploratory point of view much might be urged in favour of an Antarctic Expedition at an early date; for the further progress of scientific geography it is essential to have a more exact knowledge of the topography of the Antarctic regions. This would enable a more just conception of the volume relations of land and sea to be formed, and in connexion with pendulum observations some hints as to the density of the sub-oceanic crust and the depth of ice and snow on the Antarctic continent might be obtained. In case the above sketch may possibly have created the impression that we really know a great deal about the Antarctic regions, it is necessary to re-state that all the general conclusions that have been indicated are largely hypothetical, and to again urge the necessity for a wider and more solid base for generalisations. The results of a successful Antarctic Expedition would mark a great advance in the philosophy—apart from the mere facts—of terrestrial science.

No thinking person doubts that the Antarctic will be explored. The only questions are: when? and by whom? I should like to see the work undertaken at once, and by the British Navy. I should like to see a sum of £150,000 inserted in the Estimates for the purpose. The Government may have sufficient grounds for declining to send forth such an expedition at the present time, but that is no reason why the scientific men of the country should not urge that the exploration of the Antarctic would lead to important additions to knowledge, and that, in the interests of science among English speaking peoples, the United Kingdom should take not only a large but a leading part in any such exploration.

Remarks by the Duke of Argyll.

Scientific men generally feel, I think, that they do not need to give detailed reasons in connexion with particular subjects of inquiry, to justify their unanimous desire for an Antarctic Expedition. It is enough, surely, for them to point out the fact that a very large area of the surface of our small planet is still almost unknown to us. That it should be so seems almost a reproach to our civilisation. As to detailed reasons, it may almost be said with truth that there is hardly one of the physical sciences on which important light may not

be cast by Antarctic exploration. Oceanic circulation; meteorology; magnetism; distribution of animal and vegetable life, not only in the present but in the past; geology; mineralogy; volcanic action under special conditions—all of these are subjects on which the phenomena of the Antarctic regions are sure to bear directly.

If, however, I am asked to specify more particularly the question on which I look for invaluable evidence which can be got nowhere else, I must name, above all others, the most difficult questions involved in quaternary geology. Geologists are nearly all agreed that there has been, very recently, a glacial age—an age in which glacial conditions prevailed over the whole northern hemisphere to a much lower latitude than they prevail now. But geologists differ widely and fundamentally from each other as to the form which glacial agencies took during that period. In particular, many geologists believe in what they call an “ice sheet”—that is to say, in the northern world having been covered by an enormous mass of ice several thousand feet thick, which, as they assert, “flowed” over mountain areas as well as over plains, and filled up the bed of seas of a considerable depth. Other geologists disbelieve in this agency altogether. They deny that even if such a body of ice ever existed, it could possibly have moved in the way which the theory assumes. They affirm, also, that the facts connected with glaciated surfaces do not indicate the planing down by one universal sheet of enormous weight and pressure; but, on the contrary, the action of small and lighter bodies of ice, which have acted partially and unequally on different surfaces differently exposed.

We might have hoped that this controversy could be settled by the facts connected with the only enormous ice-sheet which exists in the Northern Hemisphere, viz., that which covers the great continent of Greenland. But that ice-sheet, enormous though it be, does certainly not do what the ice-sheet of the Glacial Age is supposed to have done. That is to say, it does not flow out from Greenland, fill the adjacent seas, or override the opposite coasts, even in so narrow a strait as Smith’s Sound. But this evidence is negative only. In the Antarctic continent we have reason to believe that there is a larger ice-sheet, and it certainly does protrude into the adjacent seas, not merely by sending out vast floating fragments, but in unbroken ice cliffs of great height. Now we want to know exactly under what conditions this protrusion takes place. Dr. Murray speaks of it as “creeping” seawards—a more cautious word than “flowing.” But is it certain that it does even creep? May it not simply grow by accretion or aggregation till it reaches a depth of water so great as to break it off by floatation? Does it, or does it not, carry detritus when no detritus has been dropped on its surface? Or does it pick up detritus from its own bed? Or does

it push foreign matter before it? Is the perfectly tabular form of the Antarctic icebergs compatible with any differential movement in the parent mass at all; or does it not indicate, on the contrary, a condition of immobility until their buoyancy lifts great fragments off? What is the condition of the rocks on which they rest? Is there any thrust upon the mass from the mountain ranges on which the gathering ground lies? Or is the whole country one vast gathering ground from the continual excess of precipitation over melting? These questions, and a hundred others, have to be solved by Antarctic discovery; and until they are solved we cannot argue with security on the geological history of our own now temperate regions. The Antarctic continent is unquestionably the region of the earth in which glacial conditions are at their maximum, and therefore it is the region in which we must look for all the information attainable towards, perhaps, the most difficult problem with which geological science has to deal.

Remarks by Sir J. D. Hooker.

Dr. Murray's admirable summary of the scientific information obtainable by an organised exploration of the Antarctic regions leaves nothing further to be said under that head. I can only record the satisfaction with which I heard it, and my earnest hope that it will lead to action being taken by the Government in the direction indicated.

Next to a consideration of the number and complexity of the objects to be attained by an Antarctic expedition, what dwells most in my imagination is the vast area of the unknown region which is to be the field for investigation—a region which in its full extension reaches from the latitude of 60° S. to the Southern Pole, and embraces every degree of longitude. This is a very considerable portion of the surface of the globe, and it is one that has been considered to be for the most part inaccessible to man. I will therefore ask you to accompany the scientific explorer no further than to the threshold of the scenes of his labours, that you may see how soon and how urgently he is called upon to study some of those hitherto unsolved Antarctic problems that he will there encounter.

In latitude 60° S. an open ocean girdles the globe without break of continuity. Proceeding southwards in it, probably before reaching the Antarctic circle, he encounters the floating ice fields which form a circumpolar girdle, known as "the Pack," approximately concentric with the oceanic, interrupted in one meridian only, that south of Cape Horn, by the northern prolongation of Graham's Land. Pursuing his southward course in search of seas or lands beyond, after the novelty of his position in the pack has worn off, he

asks where and how the components of these great fields of ice had their origin, how they arrived at and maintain their present position, what are their rate of progress and courses, and what their influence on the surrounding atmosphere and ocean. I believe I am right in thinking that to none of these questions can a fuller answer be given than that they originated over extensive areas of open water in a higher latitude than they now occupy, that they are formed of frozen ocean water and snow, and that winds and currents have brought them to where we now find them. But of the position of the southern open waters, with the exception of the comparatively small area east of Victoria Land,* we know nothing, nor do we know anything of the relative amount of snow and ice of which they are composed, or of their age, or of the winds and currents that have carried them to a lower latitude.

The other great glacial feature of the Antarctic area is "the Barrier," which Ross traced for 300 miles, in the 78th and 79th degrees of S. latitude, maintaining throughout the character of an inaccessible precipitous ice-cliff (the sea-front of a gigantic glacier) of 150—200 feet in height. This stupendous glacier is no doubt one parent of the huge table-topped ice-islands that infest the higher latitudes of the Southern Ocean; but, as in the case of the pack ice, we do not know where the barrier has its origin, or anything further about it, than that it in great part rests on the bottom of a comparatively shallow ocean. It probably abuts upon land, possibly upon an Antarctic continent; but to prove this was impossible on the occasion of Ross's visit, for the height of the crow's nest above the surface of the sea was not sufficient to enable him to overlook the upper surface of the ice, nor do I see any other way of settling this important point except by the use of a captive balloon—an appliance with which I hope any future expedition to the Antarctic regions will be supplied. There were several occasions on which such an implement might have been advantageously used by Ross when he was coasting along the barrier; and there were more when it would have greatly facilitated his navigation in the Pack.

I have chosen the subject of the Antarctic ice as the theme for my acknowledgment of the honour you have done me in asking me to address this most important meeting, not only because it is one of the very first of the phenomena that demand the study of the explorer, but because it is the dominant feature in Antarctic navigation, where the ice is ever present, demanding, whether for being

* I refer to the "pancake" ice, which in that area on several occasions formed with great rapidity around Ross's ships, lat. 76° to 78° S., in February, 1842, and which arrested their progress. Such ice, augmented by further freezing of the water and by snow, may be regarded as the genesis of fields that, when broken up by gales, are carried to the north and contribute to the circumpolar pack.

penetrated or evaded, all the commander's fortitude and skill and all his crew's endurance.

It may be expected that I should allude to those sections of Dr. Murray's summary that refer to the Antarctic fauna and flora. They are most important, for the South Polar Ocean swarms with animal and vegetable life. Large collections of these, taken both by the tow-net and by deep sea soundings, were made by Sir J. Ross, who was an ardent naturalist, and threw away no opportunity of observing and preserving; but unfortunately, with the exception of the *Diatomaceæ* (which were investigated by Ehrenberg), very few of the results of his labour in this direction have been published. A better fate, I trust, awaits the treasures that the hoped-for expedition will bring back, for so prolific is that ocean that the naturalist need never be idle, no, not even for one of the twenty-four hours of daylight during a whole Antarctic summer, and I look to the results of a comparison of the oceanic life of the Arctic and Antarctic regions as the heralding of an epoch in the history of biology.

Remarks by Dr. G. Neumayer.

With great pleasure I accepted the invitation to attend a discussion meeting on the importance, for the advancement of every branch of science, of a scientific exploration of the Antarctic region. Regardless of the season and my advanced age, I hastened here to speak in the presence of so high a forum as the Royal Society of London, on the necessity of despatching as soon as possible an expedition towards the South Pole—an expedition cannot be dispensed with if we seriously desire the advancement of nearly every branch of human knowledge. It is fifty-five years ago since one of the greatest Arctic and Antarctic explorers ceased his work, so exceedingly well executed, in the Antarctic regions, and, since that time, it has never been taken up in any way comparable with that glorious scientific and nautical spirit manifested by Sir James Clark Ross. It is in view of this fact that we all look to the British nation as the one destined to carry on the exploration of the South Polar regions, and to assist this object as much as lay in my power, and to do homage to the memory of Ross, I could not fail to appear at this meeting.

It is indeed a matter of great interest to examine the reason why so long a time has been allowed to elapse since the first great successes in the middle of this century. Undoubtedly political questions have interfered in an unusual manner so to retard progress in Antarctic inquiry, but it is not that alone; the cause is mainly that the thorough understanding of the importance of Antarctic research requires an unusual amount of knowledge, and not in one branch of science only, but in the whole complex of natural philosophy and

natural science. The positive advantages to be derived from a renewal of Antarctic exploration appear but few at first glance, and can only be detected by a far-sighted man. The Royal Geographical Society has taken up the agitation for that renewal. The Sixth International Geographical Congress, two and a half years ago, devoted its influential exertions to the recommendation of it to the Government, not only of this country, but, indeed, of all civilised countries. But now that the Royal Society has taken the matter up (an example which will be followed, I am convinced, by other academies of science), final success may be looked upon as matter of certainty.

However much as has been done already to urge the importance of the scientific investigation of the South Polar regions, from as many points of view as there are branches of science cultivated by mankind, I consider it my duty, as a representative of geophysical science, to add all the arguments in my power to those brought forward on the part of geologists, zoologists, botanists, and others.

A gravitation survey in connection with a thorough geographical exploration of the Antarctic, is one of the most urgent requirements of the science of our earth. There are no measurements of the gravitation constant within the Antarctic region, indeed they are very scarce in the southern hemisphere south of 30° south latitude. Such measurements are so closely connected with the theory of the figure of our earth, that it may well be asked how it can be considered possible to achieve any advance in this respect, to arrive at any conclusive results in this all-important fundamental matter, without observations within the Antarctic region. It is impossible to foretell what effect an exact gravitation survey in that region might exert upon our views with regard to all physical and terrestrial constants, which depend on the radius of our earth. Apart from that consideration, we may hope for another important enlargement of our knowledge bearing upon the connection between terrestrial magnetism and gravity. Gravity observations have been so much simplified of late by von Sterneck's ingenious apparatus, that there is no serious difficulty in so multiplying gravity determinations within the Antarctic region, that we shall be quite justified in speaking of a "gravitation survey." The all-important question of the distribution of land within the South Polar region is closely connected with it, and our leading authority on geodesy, Professor Helmert, justly lays great stress upon the observation of the force of gravity south of 60° south latitude. He induced the International Geodetic Permanent Commission to express it as their conviction that a gravitation survey within that region would be of the greatest benefit for higher geodetic theory (October, 1895).

I have already alluded to the probable connection between gravity

and terrestrial magnetism. But apart from that, a magnetic survey of the Antarctic region is of the greatest importance from other points of view. As, since the time of Ross, no fresh observations on the values of the magnetic elements have been made, we are entirely ignorant of the values of the secular variation south of 50° latitude, data so much needed for the construction of reliable magnetic charts. Of the situation of the southern magnetic pole, and of its motion during the last fifty years, we are equally ignorant. The situation of the southern extremity of the earth's magnetic axis and its motion throughout half a century are extremely important according to Gauss's theoretical deductions. All computations, however intricate, must prove incomplete, and inadequately reward the immense amount of labour bestowed upon them, unless reliable values of the magnetic elements are first obtained, for which purpose a reduction to a certain epoch by means of secular changes is indispensable. But not merely for theoretical purposes is such value to be put upon the knowledge of the magnetic character in the Antarctic, but also for the construction of reliable magnetic charts for use in navigation. Certainly the studies of Carlheim-Gyllerskjöld and Van Bemmelen deserve great credit from a theoretical point of view, but they also cannot be carried to perfection unless we have a sound knowledge of the magnetic character of the South Polar region—at least as sound as that of the North Polar region. In the time of Ross, the magnetic Observatory at Hobart served as a safe basis for observations on terrestrial magnetism, and now the excellent Observatory at Melbourne may be turned to a similar account.

Well as the mathematical theory of terrestrial magnetism has been developed, of the physical theory of that mysterious natural force, we are as yet in perfect ignorance. This defect is certainly to some considerable degree caused by the deficiency of our knowledge in higher latitudes. It looks as if the magnetic character of the South Polar region were such as would afford every facility for a sound investigation when brought into comparison with the magnetic conditions of the North Polar region. A glance at the map shows how entirely different is the distribution of the magnetic force (action) in the two polar regions. In the south there is to be noticed the interesting fact that the two foci of total intensity are both situated on the side towards the south of the Australian continent, and nearly on the same meridian.

The magnetic action which makes itself manifest by magnetic storms or disturbances reaches its highest degree likewise south of the Australian continent, whereas to the south of South America these disturbances become very scarce and of a character in point of magnitude similar to those of the temperate zones. This was most strikingly proved by the observations in Orange Bay and

South Georgia during the period of International Observations in 1882-83. Of course, the magnetic South Pole and the situation of the foci above mentioned are in close connection with these facts, but the reason for this distribution remains unexplained. In agreement with this is the relative frequency of the South Polar lights within one and the same epoch. The map here shows the results of a discussion of all observations on southern lights, and, as may be perceived at a glance, the conformity with the fact just mentioned with regard to the region of maximum disturbance is striking. It may be mentioned, also, that a discussion of the magnetic state of our earth for the epoch 1885 has yielded a curious fact (perhaps merely a coincidence), namely, that Dr. Schmidt, of Gotha, has calculated that part of the magnetic action of our earth which lies outside it, above the earth's atmosphere probably, and has arrived at the conclusion that this part amounts to about 1/50th part of the entire potential. The curves which he constructed, based on this calculation, show likewise a close coincidence with the frequency of the southern lights. This requires to be further investigated, for it is perhaps a mere coincidence. The question of atmospheric electricity, yet under the shadow of a hypothesis of more or less probability, may yield, in connection with the matters touched upon, some results more definite than science has hitherto been able to divine. Under all these circumstances we perceive that there are a number of problems yet to be solved, which must stimulate the scientific world to enter upon a close and conscientious examination of a region still enveloped in total darkness.

The necessity of climatological researches within the Antarctic region has already been so much urged that it does not appear necessary for me to enter upon the matter. That it must remain impossible to arrive at exact climatological constants, so long as we do not know the winter temperature in that large area round the South Pole and bounded by the South Polar circle, is evident to every one conversant with the subject and does not require any further illustration.

With regard to atmospheric pressure there is another curious fact which requires investigation, only to be carried on by observations within the Antarctic. The excess of barometric pressure in 35° latitude over that in 60° latitude amounts in the northern hemisphere to 19.0 mm. and in the southern hemisphere to only 3.7 mm. Here is another problem worthy of examination.

With the recital of these few facts, which suffice to prompt us to institute a vigorous examination of the South Polar regions the series is far from being exhausted. There is the question of the geoid-deformation, the phenomena of the tides, the structure of the ice and its drifting, especially the interesting fact of the appearance

of ice in lower southern latitudes, where it has never been observed since observations thereon are recorded.

The resolution of the Sixth International Congress of Geographers, assembled here in August, 1895, according to which the present century ought not to be allowed to expire without the unveiling of the mysteries of the South Polar regions, ought to be carried into execution by sending out an expedition to that end. All scientific institutions and societies have a well founded interest that such expedition should take place without further delay.

Remarks by Sir Clements Markham.

I need scarcely say how fully I concur in every word that has fallen from Dr. Murray on the subject of the scientific results, and more especially of the geographical results of an Antarctic Expedition. It is quite sufficient to point out the vast extent of the unknown area, and that no area of like extent on the surface of the earth ever failed to yield results of practical as well as of purely scientific value by its exploration.

But there is much more to be said in the present instance, because the little that we do know of the Antarctic regions points unmistakably to the very great importance and interest of the results that are certain to attend further research. The ice barrier discovered by Sir James Ross is known to be the source of the immense ice islands of the Southern Polar Sea. But it has only been seen for a distance of 300 miles. It requires far more complete examination before any approach to an adequate knowledge can be obtained respecting the extent and nature of the supposed ice cap in its rear.

We know that the Southern Continent is a region of actual volcanic activity, but the extent, nature, and effects of that activity remain to be ascertained. On the Antarctic Circle land has been sighted at numerous points, but it is unknown whether what has been seen indicates small islands or a continuous coast line.

Dr. Murray has pointed out that the whole Southern Continent is certainly not bounded by such an ice wall as was seen by Sir James Ross, and is not covered by an ice cap. But the extent of the ice cap and of the uncovered land is unknown. We are ignorant of the distribution of land and sea, and of ice and water in summer, and of the causes which influence such distribution.

The investigation of each one of these points, and of many others, will lead to further discoveries as yet undreamt of, which must needs be of the deepest interest to geographers. There are eminent scientific men present who will no doubt refer to the results of exploration in other branches of science. Combined together they make the exploration of the Antarctic regions the greatest and most important work that remains to be achieved by this generation.

Remarks by Dr. Alexander Buchan.

Dr. Alexander Buchan stated that his remarks would have exclusive reference to the first two paragraphs of Dr. Murray's address, under the heading of "The Atmosphere," but more immediately to the relation between mean atmospheric pressure and prevailing winds. He supposed he had been asked to speak on this occasion from the extensive and minute knowledge of the subject he had necessarily acquired in the preparation of the reports on atmospheric and oceanic circulation which were published as two of the reports of the scientific results of the voyage of H.M.S. "Challenger."

The former of these reports on atmospheric circulation, is accompanied by twenty-six maps showing, by isobars for each month and the year, the mean pressure of the atmosphere and by arrows the prevailing winds of the globe, on hypsobathymetric maps, or maps showing by shadings the height of the land and the depth of the sea; first, on Gall's projection, and second, on north circumpolar maps on equal surface projection. The isobars are drawn from mean pressures calculated for 1366 places, and the winds from even a larger number of places distributed as well as possible over the globe. It may also be noted that the figures showing the averages of pressure and prevailing winds are published with the report, accompaniments to maps of mean atmospheric pressure and prevailing winds of the globe not yet attempted by any other writer who has published such maps.

This, then, is the work undertaken and published in these reports, which occupied seven years in preparing as time could be spared from official duties. The result of the charting of the pressure and prevailing winds is this: Stand with your back to the wind, then the centre of lowest pressure that causes the wind is to the left in the northern hemisphere and to the right hand in the southern hemisphere, a relation well known as Buys Ballot's law. In charting the 1366 pressures and the relative prevailing winds no exception was found in any of the two hemispheres. This is one of the broadest generalisations science can point to, so far as regards what takes place in the free atmosphere.

Some years ago a theory of atmospheric circulation was published by the late Professor Ferrel, which, as it is not accordant with the broad results arrived at in the report on atmospheric circulation in the "Challenger" reports, calls for serious consideration on account of its bearing on any attempt proposed to be undertaken for the exploration of the Antarctic regions.

One of the more recent expositors of this theory is Professor Davis, of Harvard College, who, in his 'Elementary Meteorology,' Boston, U.S.A., 1894, gives an admirable exposition of the results

now arrived at by the various workers in meteorology, and of the opinions and theories promulgated by different meteorologists in different departments of the science. The book is largely used in secondary schools and colleges of the United States, and the views there stated are widely held in America and are spreading into other countries.

The following extracts from Davis's book fairly represent these views:—

“The surface winds of the temperate latitudes, and the high level currents above them, sidling swiftly along on their steep poleward gradients, must all be considered together. They combine to form a vast aerial vortex or eddy around the pole. In the northern hemisphere this great eddy is much interrupted by continental high pressure in winter or low pressure in summer, and by obstruction from mountain ranges, as well as by irregular disturbances of the general circulation in the form of storms” (p. 110).

Now the facts of observation do not support the theory of the existence at any season of the year, of a low barometric pressure, or an eddy of winds, round or in the neighbouring regions of the North Pole. Observations show us no prevailing winds blowing home-wards to the region of the North Pole at any time of the year. No low barometric pressure occupies the immediate polar region in any month; but instead the opposite holds good for the four months from April to July. In April and May the mean atmospheric pressure is higher in the region of the Pole than it is anywhere in the northern hemisphere north of 43° lat. N.; and in June and July also higher than it is anywhere north of 55° lat. N. Now the higher pressure in these four months necessitates the existence of upper currents in order to maintain this high pressure about the North Pole. These upper currents towards the pole are exactly opposed to the requirements of the theory that the upper currents in the region of the Pole must necessarily blow not towards but from the Pole.

The actual centre, in this hemisphere, north of the tropic towards which the winds on or near the surface of the earth blow, is not the North Pole; but in the winter months the low barometric depressions in the north of the Atlantic and Pacific respectively, and in the summer months the low barometric depressions in the Eurasian and North American continents; and the sources out of which the prevailing winds blow in the winter months, the high-pressure regions in Siberia and North America; and in the summer months the high-pressure regions lying northward of these continents, which, as already explained, are virtually the polar region itself. These are the facts in all regions where the winds, according to the theory, become winds blowing over the earth's surface.

As regards the southern hemisphere, Professor Davis states that :

"In the southern hemisphere the circumpolar eddy is much more symmetrically developed." Again, "the high pressure that should result from the low polar temperatures is therefore reversed into low pressure by the excessive equatorward centrifugal force of the great circumpolar whirl; and the air thus held away from the polar regions is seen in the tropical belts of high pressure" (pp. 110, 111).¹

The meaning of this is that the remarkable low-pressure region of the southern hemisphere is continued southward to the South Pole itself, the pressure diminishing all the way; and that in the region of the South Pole the air currents poured thitherwards along the surface of the earth ascend and thence proceed northwards as upper currents of such enormous intensity and volume that they pile up in the tropical region of the southern hemisphere a mean sea-level atmospheric pressure about an inch and a half higher than the sea-level pressure near the South Pole whence it has started.

Now, to bring the matter to the business which this meeting of the Royal Society has in hand—if this theory were true and supported by the facts of observation—it is plain that no meteorologist could signify his approval of any scheme that could be proposed for exploring the Antarctic regions, it being obvious that these strong west-north-westerly winds, if they blow vortically round and in upon the pole, heavily laden, as they necessarily would be, with the aqueous vapour they have licked up from the Southern Ocean, would overspread Antarctica with a climate of all but continuous rains, sleet, and snow which no explorer, however intrepid and enthusiastic, could possibly face.

But is this the state of things? Let it be at once conceded that, as far south as about 55° lat. S., the prevailing winds and the steadily diminishing mean pressures on advancing southward, fairly well support the theory. South of this, however, southerly and south-easterly winds begin to increase in frequency, until from 60° lat. S. into higher latitudes, they become the prevailing winds. This is abundantly shown from the winds charted on the maps of the "Challenger" Report, as well as from the unanimous experience of all that have navigated this region from Ross to the present time. Thus the poleward blowing winds from west-north-west in these summer months stop short, distant at least 30° of latitude from the South Pole.

These prevailing south-easterly winds necessarily imply, as has been shown in the analogous case of the North Pole, the existence of a more or less pronounced anticyclone overspreading Antarctica; which in its turn necessarily implies the existence of upper currents from the northward, blowing towards and in upon the polar region to make good the drain caused by the surface out-blowing south-

easterly winds. It may, therefore, be concluded that both the surface winds and the upper aerial currents are diametrically opposed to the requirements of this theory.

What is now urgently called for is a well-equipped Antarctic Expedition to make observations which will enable meteorologists to settle definitely the distribution of atmospheric pressure and the prevailing winds of this great region. Were this done, the position in the Southern Ocean of the great ring of lowest pressure that encircles the globe could be mapped out; and since it is towards such a low-pressure ring that the wind-driven surface currents of the ocean flow, a contribution would thereby be made to oceanography, of an importance that cannot be overestimated, particularly as regards the great question of oceanic circulation.

Remarks by Sir A. Geikie.

Hardly anything is yet known of the geology of the Antarctic regions. By far the most important contributions to our knowledge of the subject were made by the expedition under Sir James Ross. But as he was unable to winter with his ships in the higher latitudes, and could only here and there with difficulty effect a landing on the coast, most of the geological information brought home by him was gathered at a greater or less distance from the land with the aid of the telescope. Within the last few years several sealing vessels have brought home some additional scraps of intelligence which only increase the desire for fuller knowledge.

As regards the land, merely its edges have here and there been seen. Whether it is one great continent, or a succession of islands and archipelagos, may possibly never be ascertained. We know that in Victoria Land it terminates in a magnificent mountain range with peaks from 10,000 to 15,000 feet high; but that elsewhere it is probably comparatively low, shedding its ice-cap in one vast sheet into the sea.

The rocks that constitute the land are still practically unknown. The dredgings of the "Challenger" Expedition brought up pieces of granite, gneiss, and other continental rocks, and detritus of these materials was observed to increase on the sea-floor southwards in the direction of the Antarctic land. More recently several sealing vessels have brought home from the islets of Graham Land, to the south of the South Shetlands, pieces of different varieties of granite, together with some volcanic rocks and fossiliferous limestones. So far as these rocks have been studied, they do not appear to differ from similar rocks all over the globe. The granites have been found by Mr. Teall to be just such masses as might have come from any old mountain-group in Europe or America.

Among the specimens sent to me by Captain Robertson, of the

"Active," from Joinville and Dundee Islands, which form the north-eastern termination of Graham Land, there was one piece of reddish jasper which at once attracted my attention from its resemblance to the "radiolarian cherts" now found to be so widely distributed among the older Palæozoic rocks, both in the Old World and in the New. On closer examination, this first impression was confirmed; and a subsequent microscopic study of thin slices of the stone by Dr. Hinde proved the undoubted presence of abundant radiolaria. The specimen was a loose pebble picked up on the beach of Joinville Island. We have no means of telling where it came from or what is its geological age. But its close resemblance to the radiolarian cherts, so persistent in the Lower Silurian formations of the United Kingdom, raises the question whether there are not present in the Antarctic regions rocks of older Palæozoic age.

It would be of the utmost interest to discover such rocks *in situ*, and to ascertain how far their fossils agree with those found in deposits of similar antiquity in lower latitudes; or whether, as far back as early Palæozoic time, any difference in climate had begun to show itself between the polar and other regions of the earth's surface.

Among the specimens brought home by Dr. Donald and Captain Larsen from Seymour Island in the same district are a few containing some half dozen species of fossil shells, which have been named and described by Messrs. Sharman and Newton, who suggest that they point to the existence of Lower Tertiary rocks, one of the organisms resembling a form found in the older Tertiary formations of Patagonia. Large, well-developed shells of *Cucullæa* and *Cytherea* undoubtedly indicate the former existence of a far milder climate in these Antarctic seas than now prevails.

If a chance landing for a few hours on a bare islet could give us these interesting glimpses into the geological past of the south polar regions, what would not be gained by a more leisurely and well planned expedition?

But, perhaps, the geological domain that would be most sure to gain largely from such exploration would be that which embraces the wide and fascinating field of volcanic action. In the splendid harvest of results brought home by Sir James Ross, one of the most thrilling features was the discovery of a volcano rising amid the universal snows to a height of more than 12,000 feet, and actively discharging "flame and smoke," while other lofty cones near it indicated that they too had once been in vigorous eruption. Ross landed on one or two islands near that coast and brought away some pieces of volcanic rocks.*

If we glance at a terrestrial globe we can readily see that the

* His collections are in the British Museum, but they have never been petrographically studied.

volcanic ring or "circle of fire," which nearly surrounds the vast basin of the Pacific Ocean, stretches southwards into New Zealand. The few observations that have been made in the scattered islands further south show that the Auckland, Campbell, and Macquarrie groups consist of, or at least include, materials of volcanic origin. Still further south, along the same general line, Mr. Borchgrevink has recently (1894-95) made known the extension of Ross's volcanic region of Mount Erebus northwards to Cape Adare, the northern promontory of Victoria Land. He noticed there the apparent intercalation of lava and ice, while bare snowless peaks seemed still further to point to the continued activity of the volcanic fires. Some specimens, brought by Captain Jenssen, from Possession Island were found by Mr. Teall to be highly vesicular hornblende-basalt; while one from Cape Adare was a nepheline-tephrite. This region is probably one of the most interesting volcanic tracts on the face of the globe. Yet we can hardly be said to know more of it than its mere existence. The deeply interesting problems which it suggests cannot be worked out by transitory voyagers. They must be attacked by observers stationed on the spot. Ross thought that a winter station might be established near the foot of Mount Erebus, and that the interior could easily be traversed from there to the magnetic pole.

But it is not merely in Victoria Land that Antarctic volcanoes may be studied. Looking again at the globe, we observe that the American volcanic band is prolonged in a north and south line down the western side of the southern continent. That it has been continued into the chain of the South Shetlands and Graham Land is proved by the occurrence there of old sheets of basalt, rising in terraces over each other, sometimes to a height of more than 7,000 feet above the sea. These denuded lavas may be as old as those of our Western Isles, Faroe, Iceland, and Greenland. But that volcanic activity is not extinct there has recently been found by Captain Larsen, who came upon a group of small volcanoes forming islets along the eastern coast line of Graham Land. It is tantalising to know no more about them.

Another geological field where much fresh and important information might be obtained by Antarctic exploration is that of ice and ice action. Our northern hemisphere was once enveloped in snow and ice, yet although for more than half a century geologists have been studying the traces of the operations of this ice covering, they are still far from having cleared up all the difficulties of the study. The Antarctic ice-cap is the largest in the world. Its behaviour could probably be watched along many parts of its margin, and this research would doubtless afford great help in the interpretation of the glaciation of the northern hemisphere.

To sum up :—Geologists would hail the organisation and despatch of an Antarctic Expedition in the confident assurance that it could not fail greatly to advance the interests of their science. Among the questions which it would help to elucidate, mention may be made of the following :—

The nature of the rocks forming the land of the Antarctic regions and how far these rocks contain evidence bearing on the history of terrestrial climates.

The extent to which the known fossiliferous formations of our globe can be traced towards the poles; the gaps which may occur between these formations and the light which their study may be able to throw on the evolution of terrestrial topography.

The history of volcanic action in the past and the conditions under which it is continued now in the polar regions; whether in high latitudes volcanism, either in its internal magmas or superficial eruptions, manifests peculiarities not observable nearer to the equator; what is the nature of the volcanic products now ejected at the surface; whether a definite sequence can be established from the eruptions of still active volcanoes back into those of earlier geological periods; and whether among the older sheets leaf-beds or other intercalations may be traceable, indicating the prolongation of a well developed terrestrial flora towards the South Pole.

The influence of the Antarctic climate upon the rocks exposed to its action; the effects of contact with ice and snow upon streams of lava; the result of the seaward creep of the ice-cap in regard to any lava sheets intercalated in the ice.

The physics of Antarctic ice in regard to the history of the Ice Age in Northern Europe and America.

Remarks by Professor D'Arcy W. Thompson.

The exploration of the Antarctic gives promise of gains to zoological knowledge that are in no degree less, in my opinion, than in the case of the physical sciences. The shore-fauna of the Antarctic we know only by a few scanty collections made upon the islands, especially upon Kerguelen Island; and the fauna of the deep sea is only represented by the produce of eight hauls of the "Challenger's" dredge. These few dredgings gave evidence of peculiarly abundant life, indeed they were said, by common consent of the naturalists of the "Challenger," to be the richest dredgings in all her voyage: and they were as remarkable for the diversity as for the abundance of the animals they procured. We earnestly desire, and the progress of zoological science needs, further exploration of the deep-sea fauna in all the oceans. Our knowledge of the fauna of the deep sea is only begun; it is known much as the fauna of the

shore was known a hundred years ago, and we want to know more of the undiscovered forms that are peculiar to it, and more of the structure and affinities of those already discovered. But apart from innumerable facts appertaining to systematic or morphological zoology, such as every ocean has yet to yield to us, there are certain great problems of geographical distribution to which the Antarctic is peculiarly likely to give a clue. Lying open to, as it were at the confluence of, all the great oceans, its fauna may co-ordinate and explain many things in the divergent faunas of the Indian Ocean, the Atlantic, and the Pacific. One such problem Dr. Murray has touched upon in his hypothesis of "bipolar distribution," that is to say, of a general similarity and in many cases of actual identity between the animals of the Arctic and Antarctic Seas. This theory has been proclaimed before by others, by Théel, for instance, and by Pfeffer; but others have contested and denied it; for instance, Ortmann in regard to the crustacea, and Chun in regard to pelagic organisms. We could not have a better illustration of the poverty of our knowledge than the circumstance that so broad and clear and simple an issue as the existence or non-existence of a close relation between the Arctic and Antarctic faunas should still be open to dispute.

For my part I think that the bipolar hypothesis is not proven, and I am inclined to think it is untrue. I believe with Ortmann that in the Decapod crustacea at least one form is common to the Arctic and Antarctic Seas; and with Chun and others that there is evidence that similar pelagic forms occurring in the north and south, though not in the surface waters of the tropical seas, are in these latter continued across the torrid zone in the deeper and cooler levels of the sea. I do not think that any single fish, or any Decapod or Isopod, or any certain one out of a large fauna of Amphipods known from the Antarctic Ocean, is also known from the Arctic and adjacent seas. It seems to me, however, that we have some good evidence of very curious similarities between the marine fauna of the Antarctic and that of the N. Pacific in the neighbourhood of Japan; and it may be that this is to be in part explained by the existence of a line of communication along the Western American coast, in waters singularly cold for the latitude under which they lie. We know how, in this way, such conspicuous forms as the genus *Serolis*, the Penguins, the Sea-elephant, the Sea-lions, and the Fur-seals, I might add the giant Sea-weed *Macrocystis* seem to creep up the American shore, from what was probably their Antarctic home, to Chili, to the Galapagos, or even to North Pacific and to Japan. But these are illustrations merely of the zoological problems that Antarctic exploration may solve. If the bipolar hypothesis be broken down, it will only give place to other hypotheses as interesting as itself. New facts will give rise to new hypotheses, for further facts to verify

or to disprove, and the Antarctic holds for us innumerable problems of which we can foresee neither statement nor solution, as well as the solution of those that we can already in some measure foresee.

“On the Zoological Evidence for the Connection of Lake Tanganyika with the Sea.” By J. E. S. MOORE, A.R.C.S. Communicated by Professor LANKESTER, F.R.S. Received January 12,—Read January 27, 1898.

(From the Huxley Research Laboratory, Royal College of Science, London.)

Before 1896, when I had the opportunity of studying the fauna of Lake Tanganyika on the spot, it was known that there existed in the so-called Sea of Ujiji, one animal, the affinities of which are undoubtedly marine. This was the medusa *Limnocyda*, which Dr. Boehm saw as he crossed the lake in 1883.

It was known further that the jelly-fish was associated in Tanganyika with a number of strange molluscan forms, for the empty shells of what appeared to be some six entirely new genera of gasteropods, had been brought home by Captain Speke, Joseph Thomson, and Mr. Hore. As the animals contained in these shells have not hitherto been known, their classification by the conchologists with existing fresh-water types has always appeared extremely doubtful, and from the first Mr. Edgar Smith, who described the greater number of these forms, has held the opinion that they might eventually turn out to have the same oceanic characters as the jelly-fish.

It was therefore one of the objects of my recent expedition to obtain material for the complete determination of these molluscan types, and especially to ascertain if there were any other marine organisms in the lake. The results of this attempt have been to show:—

I. That to the six genera of quasi-marine gasteropods, the shells of which were known, viz., *Typhobia*, *Nassopsis*, *Limnotrochus*, *Syrnolopsis*, the so-called *Lithoglyphus*, and *Paramelania*, there are now to be added at least two, entirely new generic forms, for which I propose the names* *Bathanalia* and *Bythoceras* (figs. 1 and 2). We have therefore now representing the quasi-marine molluscs of Tanganyika eight genera of gasteropods, and to these should probably be added among the Lamellibranchiata the so-called *Unio Burtoni* and one of the Tanganyika Spathas.†

* Diagnoses of these new genera will be found in papers now in the hands of the Editor of the ‘Quart. Journ. Mier. Sci.’

† Complete accounts of the anatomy of all these Halolimnic genera will shortly appear in the ‘Quart. Journ. Mier. Sci.’